Gone with the Flood: Natural Disasters, Selective Migration, and Media Awareness

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Motivation: Higher Flood Risk due to Climate Change

2021 Washington, U.S. (Grist, Sep 2022)

2022 Jaffarabad, Pakistan (CNN, August 2022)

2023 Chongqing, China (Guardian, July 2023)

- Flood risk expected in US to grow by 26.4% by 2050 (Wing et al., 2022)
- Estimated average annual loss USD32.1 billion (Kocornik-Mina et al., 2020)
- 42% of U.S. population living in coastal areas (Fleming et al., 2018)
- 2.5 million properties at risk of chronic flood by the end of this century (Dahl et al., 2018)

Human Settlement Alters in Response to Flood Risks

- 650 million people worldwide displaced by floods in past 3 decades (Rigaud et al., 2018)
- Compare Inter-state Migration and Flood Risks in the US:

Figure 1a. Net Inflow in the US: 2005-2019

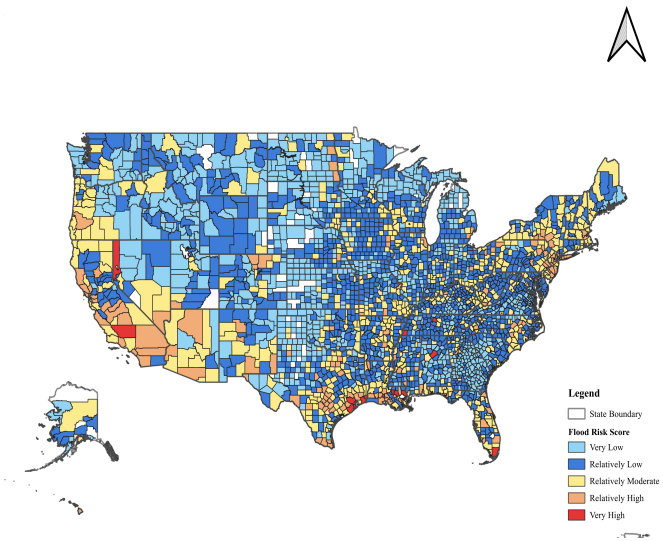


Figure 1b. Flood risk in the United States

Data sources: State-to-state migration flows are from United States Census Bureau; National risk index are from Federal Emergency Management Agency

Puzzling Mixed Empirical Findings!

- Strong net outflow migration in some cases (Hornbeck & Naidu, 2014 AER; Chen et al., 2017 AER)
- Little net migration in other cases (Bohra-Mishra et al., 2014 PNAS)
- Potential reasons:
  - Post-disaster recovery plans (Jia et al., 2022 WP; Deng et al., 2023 WP)?
  - Lower housing prices, better affordability (Bernstein et al., 2019 JFE)?
  - Different beliefs in future flood risks (Bernstein et al., 2022 JFE)?

Disclosure of Climate Risk and Household Decisions

- Hino and Burke (2021 PNAS): Flood risk not fully capitalized in US housing markets due to information barrier
- Richler (2019 Nature Climate Change): Information nudge on flooding can increase willingness to pay for flood insurance
- Lee (2022 WP): Information provision on flood risk in flood-prone zones results in population decline
- Chelli (2023 Nature Water): Communities' risk perceptions lessen flood hazards impact by supporting decisions improving infrastructure

Research Questions

1. Can flood risks trigger **"selective migration"**?
2. Are there discernible differences in **socioeconomic profiles** of migration inflows and outflows?
3. What is the role of **media** in flood-induced migration?

Overview

- Combine data of migration, flood events, newspapers, and housing in US 2005-2019
- DID estimation on impact of floods on selective migration:
  - Significant increase in both outflow (2.7%) and inflow migration (1.9%) after floods at the county-year level
  - Heterogeneity analysis reveals local population replacement:
    - Move out: higher-education, employed, and younger individuals
    - Move in: lower-education, unemployed, and older individuals
  - Media sentiment exaggerates the selective migration pattern
  - Short-term consequence: housing price decreases (2%); rent increases (3%)
  - Long-term consequence: back-of-envelope estimates of US$2-9 million annual losses per county

Contributions

1. First to uncover the selective migration post-disaster
   - different from prior studies focusing on net or outflow migration (Bohra-Mishra et al., 2014; Hornbeck, 2012)
2. Media awareness of natural disaster risks impacts residential location choices (Hino & Burke, 2021; Lee, 2022)
   - exaggerates heterogeneity and inequality; ramifications in regional disparity
3. New channel in understanding post-flood housing market dynamics
   - a wealth effect beyond direct damage or risk perception (Bernstein et al., 2022)

Dataset

- American Community Survey: Outflow and inflow migration at the county level in 2006-2019
- National Center for Environmental Information: All flood events in the US at the county level in 1950-present
- Factiva: Sentiment in newspapers on flood-related themes at state-year level
- Zillow: Housing price (ZHVI, 2006-2019) and rent (ZORI, 2015-2019) index
- Other control variables: Macroeconomic factors (US BEA); post-disaster recovery fund (OpenFEMA); firm entry/exit (Augmented 10-X Header)

Dataset 1: Migration

- Annual American Community Survey (ACS) 2005-2019: individual migration data from 600 counties
- Socioeconomic and demographic characteristics, e.g., age, educational attainment, migration, previous and current county of residence
- Define movers as migrating out of origin county $\rightarrow$ construct year-county annual outflow migration (based on county one year before migration) $\rightarrow$ construct year-county annual inflow migration (based on current county)
- Heterogeneity: education, employment status, age

Dataset 2: Flood

- 48 different types of nature disaster events in 3,234 counties since 1950
- Information on location (states, counties, and zones), start time, end time, number of injured victims, damages of property
- 205 counties with floods as treatment group $\rightarrow$ adjacent 365 counties with no floods as control group $\rightarrow$ [-3, 3] years window

Dataset 3: Newspapers

- 16,838 pieces of newspaper articles related to floods from 5 major daily US-based newspapers (*Wall Street Journal, New York Times, USA Today, Washington Post, Los Angeles Times*) from Factiva
- Extract state information, calculate sentiment score of each sentence using natural language processing (NLP) algorithms, and generate average sentiment scores for each article
- Standardize the score within (-1, 1):
  - Negative: *"...The early estimates suggested insured property damage around $5 billion or less from Hurricane Rita, not including the effects of flooding and the impact on offshore oil rigs, which are excluded in most of the calculations. The storm struck less heavily populated areas, with less force than Hurricane Katrina, mostly bypassing Galveston, Tex., and Houston, where damage up to $30 billion had been feared..."*
  - Positive: *"...That deal would create a December deadline for the debt limit and the spending package. McConnell said that he would be supportive of the plan and intended to offer it as an amendment to the flood relief bill that passed the House on Wednesday..."*

Summary Statistics

Panel A: Number of Outflow Migrants

	Obs	Mean	SD
Total	16,405	169.85	160.71
– Higher-educated (in or above college degree)	16,405	62.16	67.30
– Lower-educated (below college degree)	16,405	106.58	99.55
– Employed	16,405	127.71	120.72
– Unemployed	16,405	42.14	44.51
– Young ($<$ 40 years old)	16,405	126.18	119.07
– Old ($\geq$ 40 years old)	16,405	43.67	43.33

Panel B: Number of Inflow Migrants

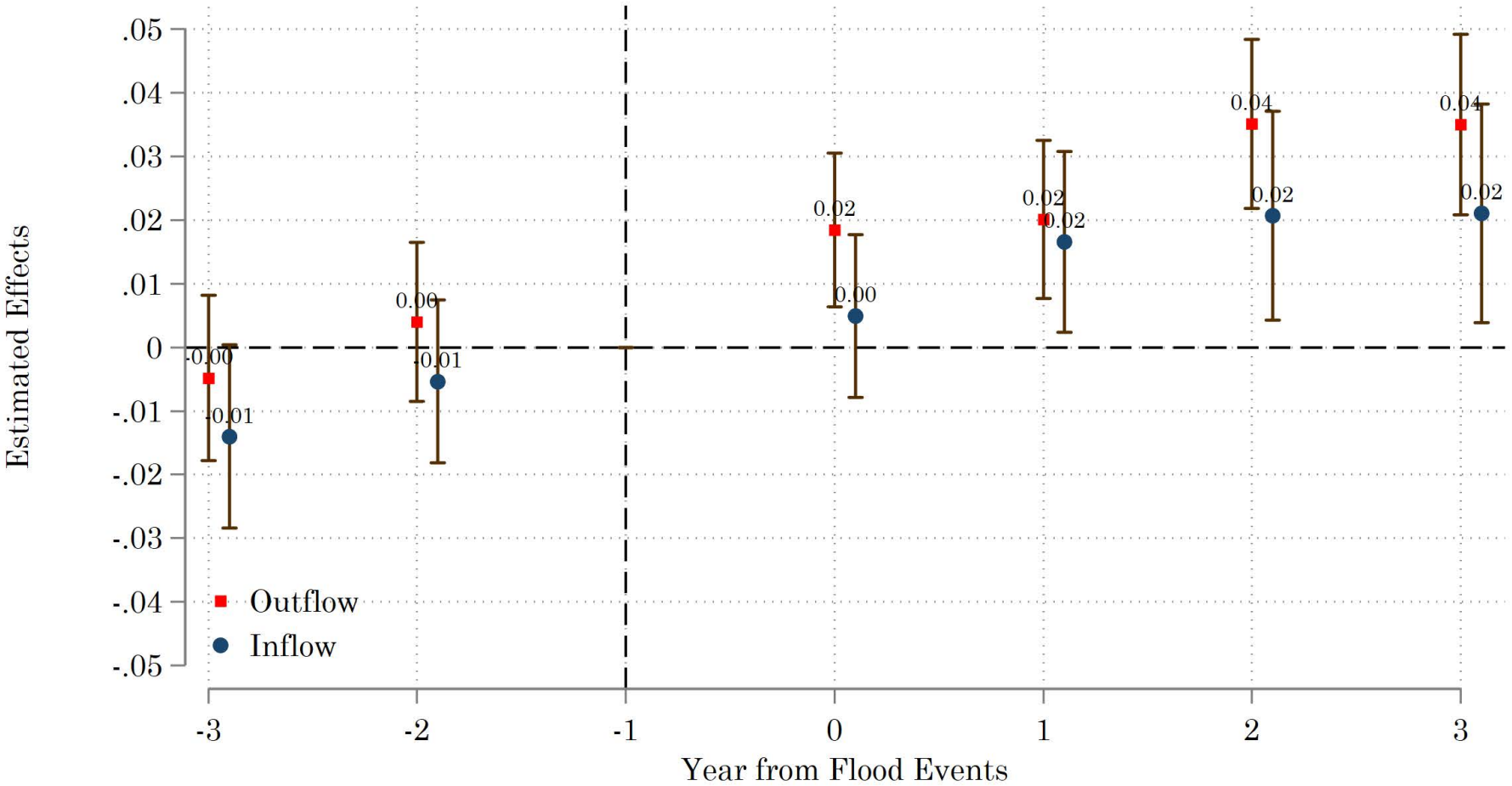
	Obs	Mean	SD
Total	16,405	167.09	158.15
– Higher-educated (in or above college degree)	16,405	62.25	71.72
– Lower-educated (below college degree)	16,405	103.68	95.45
– Employed	16,405	126.54	120.43
– Unemployed	16,405	40.55	45.51
– Young ($<$ 40 years old)	16,405	124.62	118.87
– Old ($\geq$ 40 years old)	16,405	42.47	43.57

Identification Strategy: Stacked Spatial DID Model

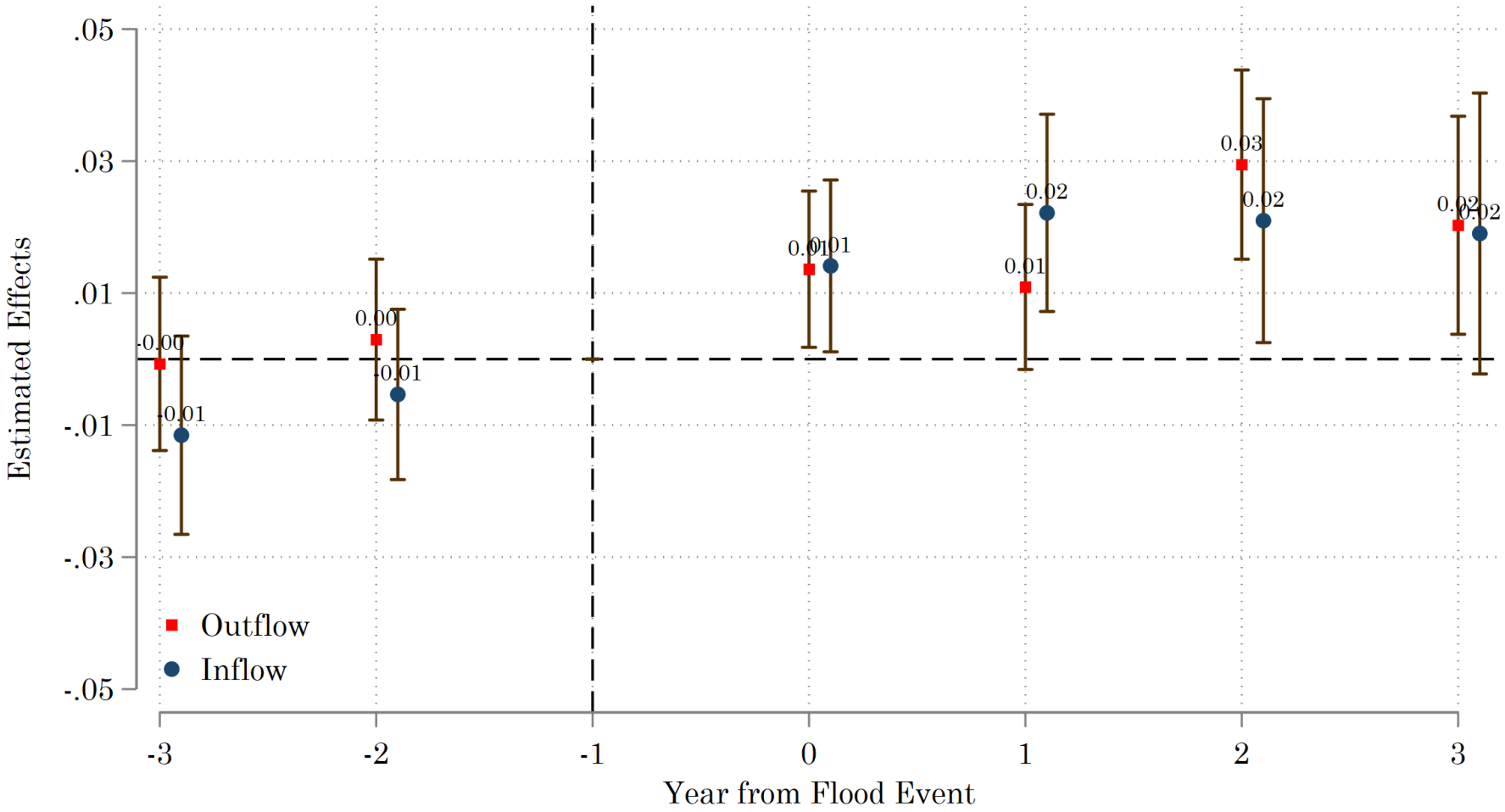
$$Y_{ijt} = \beta_1 Treat_{ij} + \beta_2 Post_{jt} + \beta_3 Treat_{ij} \times Post_{jt} + X'_{ijt}\lambda_X + \omega_i + \theta_t + \rho_j + \mu_{st} + \epsilon_{ijt} \quad (1)$$

- Y_{ijt}: outflow/inflow migration for county i in year t affected by flood j
- $Treat_{ij}$: equals 1 if county i is subject to flood j
- $Post_{jt}$: equals 1 if year t is after the occurrence of flood j
- X_{ijt}: control variables including unemployment rate, population, income per capita, economic loss of flood, and average housing price
- $\theta_t, \omega_i, \rho_j$: year, county, and flood fixed effects
- μ_{st}: state-by-year fixed effects
- standard errors clustered by county

Event-study Analysis (TWFE)



Event-study Analysis (CSDID)

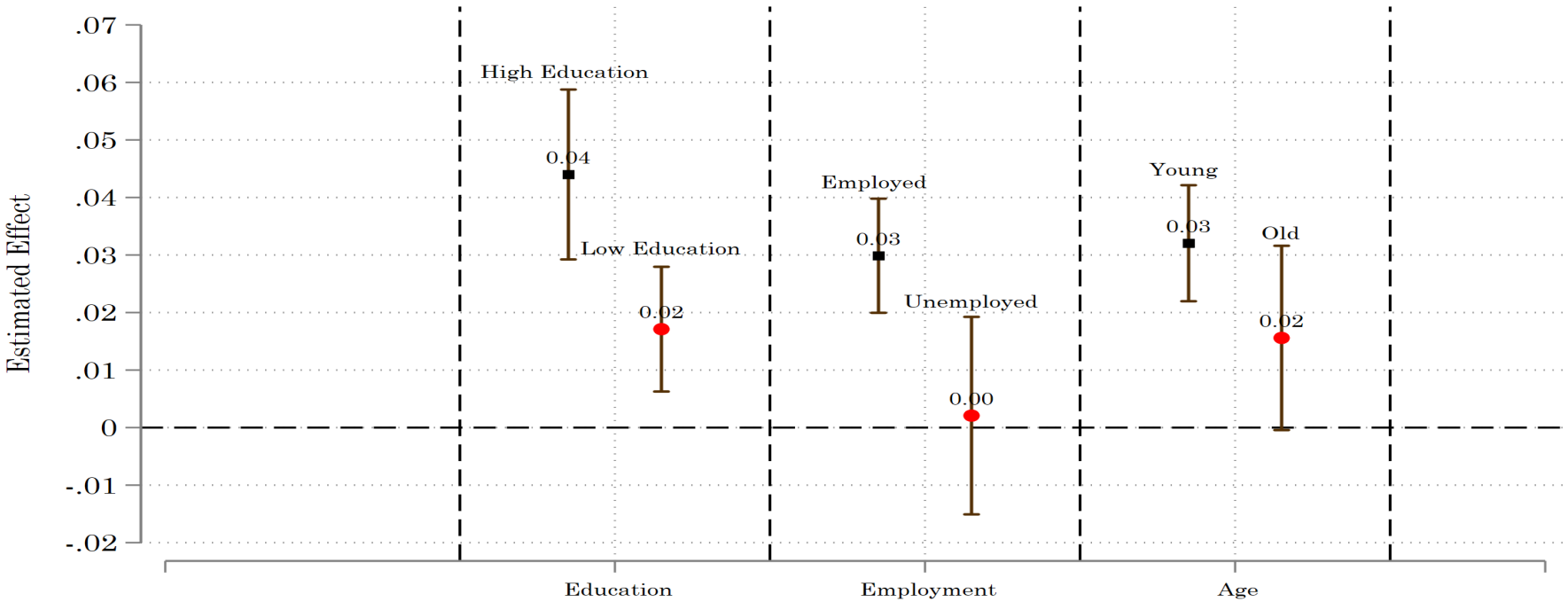


Baseline Effects

Flood risks have positive effects on outflow & inflow migration in subsequent 3 years

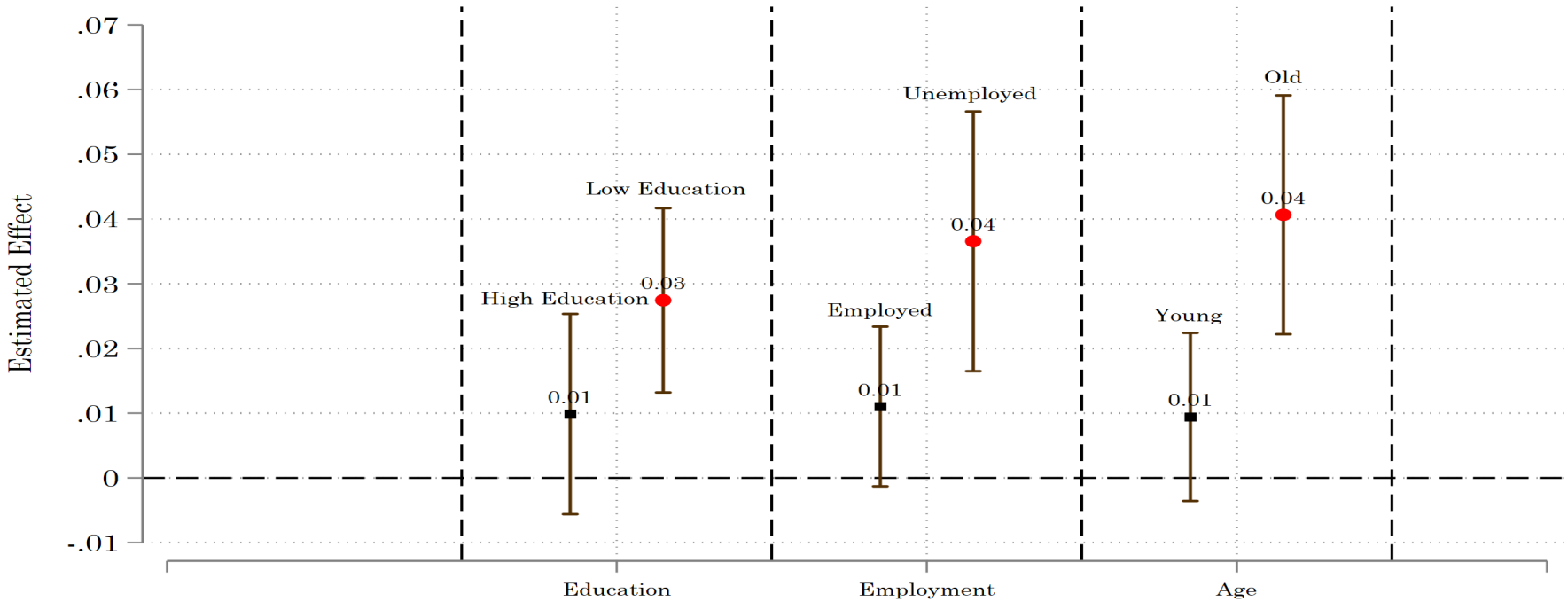
	(1) log(Outflow)	(2) log(Inflow)	(3) log(NetOutflow)	(4) Outflow	(5) Inflow	(6) NetOutflow
Treat × Post	0.027***	0.019***	0.010**	7.766***	3.552***	4.214***
	(0.005)	(0.007)	(0.004)	(1.106)	(1.281)	(1.601)
Macroeconomic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Flood Event Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
State-year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,405	16,405	16,405	16,405	16,405	16,405
R-squared	0.98	0.97	0.69	0.99	0.98	0.70
Mean Dependent Variable	4.83	4.80	5.92	169.85	167.09	2.76

Selective Migration: Outflow



Note: High (low) education refers to migrants with degrees at or above (below) the college level. Employed (unemployed) individuals are classified by their employment status in 1 year before the flood. Young (old) individuals are those under (in or above) the age of 40. Error bars indicate 90% confidence intervals.

Selective Migration: Inflow



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Media Sentiment

Panel A. Outflow Migration

	(1) Total log(Outflow)	(2) High Education log(Outflow)	(3) Low Education log(Outflow)	(4) Employed log(Outflow)	(5) Unemployed log(Outflow)	(6) Young log(Outflow)	(7) Old log(Outflow)
Treat × Post × Score	-0.016***	-0.028***	-0.012**	-0.016***	-0.009	-0.018***	-0.013
	(0.005)	(0.007)	(0.006)	(0.005)	(0.008)	(0.005)	(0.008)
Treat × Post	0.022***	0.036***	0.013*	0.025***	-0.000	0.027***	0.012
	(0.006)	(0.009)	(0.007)	(0.006)	(0.011)	(0.006)	(0.010)
Observations	16,405	16,405	16,405	16,405	16,405	16,405	16,405
R-squared	0.98	0.96	0.96	0.97	0.93	0.97	0.93

Panel B. Inflow Migration

	(1) Total log(Inflow)	(2) High Education log(Inflow)	(3) Low Education log(Inflow)	(4) Employed log(Inflow)	(5) Unemployed log(Inflow)	(6) Young log(Inflow)	(7) Old log(Inflow)
Treat × Post × Score	0.010*	-0.000	0.016**	0.004	0.024***	0.010	0.016*
	(0.006)	(0.007)	(0.007)	(0.006)	(0.009)	(0.006)	(0.009)
Treat × Post	0.020***	0.009	0.030***	0.011	0.042***	0.011	0.042***
	(0.007)	(0.010)	(0.009)	(0.008)	(0.012)	(0.008)	(0.012)
Observations	16,405	16,405	16,405	16,405	16,405	16,405	16,405
R-squared	0.97	0.96	0.96	0.97	0.93	0.97	0.93

Housing Market

The cumulative effects equal a 2% decrease in housing price and a 3% increase in rent in the 3-year window.

	(1) Monthly Price Growth (%)	(2) Monthly Rent Growth (%)
Treat × **Post**	-0.053***	0.074***
	(0.015)	(0.019)
Macroeconomic Controls	Yes	Yes
Flood Event Fixed Effects	Yes	Yes
County Fixed Effects	Yes	Yes
Year Fixed Effects	Yes	Yes
State-year Fixed Effects	Yes	Yes
Observations	49,845	20,208
R-squared	0.36	0.26
Mean Dependent Variable	0.48	0.32

Change in Aggregate Income (by Education)

Panel A. Outflow Migration

	High Education			Low Education		
	Lower Bound 95% CI	Mean Point Estimate	Upper Bound 95% CI	Lower Bound 95% CI	Mean Point Estimate	Upper Bound 95% CI
Change (%) in Migrants	2.64%	4.40%	6.16%	0.42%	1.70%	3.00%
× Average Migrant Population	6,216	6,216	6,216	10,658	10,658	10,658
Change (Number) in Migrants	164	274	383	45	181	320
× Average Income	51,806	51,806	51,806	15,962	15,962	15,962
Change in Aggregate Income	8,501,503	14,169,000	19,832,750	713,458	2,892,070	5,108,101

Panel B. Inflow Migration

	High Education			Low Education		
	Lower Bound 95% CI	Mean Point Estimate	Upper Bound 95% CI	Lower Bound 95% CI	Mean Point Estimate	Upper Bound 95% CI
Change (%) in Migrants	-0.86%	1.00%	2.83%	1.05%	2.70%	4.44%
× Average Migrant Population	6,225	6,225	6,225	10,368	10,368	10,368
Change (Number) in Migrants	-53	62	176	109	280	460
× Average Income	51,332	51,332	51,332	16,154	16,154	16,154
Change in Aggregate Income	-2,739,790	3,195,430	9,047,500	1,753,823	4,521,970	7,437,860

Change in Aggregate Income (by Age)

Panel A. Outflow Migration

	Young			Old		
	Lower Bound 95% CI	Mean Point Estimate	Upper Bound 95% CI	Lower Bound 95% CI	Mean Point Estimate	Upper Bound 95% CI
Change (%) in Migrants	2.00%	3.20%	4.41%	-0.35%	1.60%	3.47%
× Average Migrant Population	12,618	12,618	12,618	4,367	4,367	4,367
Change (Number) in Migrants	252	404	556	-15	70	151
× Average Income	23,740	23,740	23,740	46,087	46,087	46,087
Change in Aggregate Income	5,991,026	9,585,642	13,210,213	-705,145	3,220,210	6,978,628

Panel B. Inflow Migration

	Young			Old		
	Lower Bound 95% CI	Mean Point Estimate	Upper Bound 95% CI	Lower Bound 95% CI	Mean Point Estimate	Upper Bound 95% CI
Change (%) in Migrants	-0.61%	0.90%	2.49%	1.87%	4.10%	6.26%
× Average Migrant Population	12,462	12,462	12,462	4,247	4,247	4,247
Change (Number) in Migrants	-75	112	310	79	174	266
× Average Income	24,144	24,144	24,144	46,593	46,593	46,593
Change in Aggregate Income	-1,821,140	2,707,920	7,488,212	3,693,578	8,113,100	12,395,670

Conclusion and Policy Implication

- Flood risks increase both outflow and inflow migration significantly by 2.7% and 1.9%, respectively
- Evident heterogeneity by socioeconomic profiles:
  - higher-education, employed, and young individuals migrate out
  - lower-education, unemployed, and old migrate in
- Media sentiment exaggerates the selective migration effects
- Policy implications on post-disaster development, e.g., additional insurance to strengthen environmental justice or education policy to help the vulnerable population